

## **SMART: The Future of Spaceflight Avionics**

### **Abstract:**

A novel avionics approach is necessary to meet the future needs of low cost space and lunar missions that require low mass and low power electronics. The current state of the art for avionics systems are centralized electronic units that perform the required spacecraft functions. These electronic units are usually custom-designed for each application and the approach compels avionics designers to have in-depth system knowledge before design can commence. The overall design, development, test and evaluation (DDT&E) cycle for this conventional approach requires long delivery times for space flight electronics and is very expensive.

The Small Multi-purpose Advanced Reconfigurable Technology (SMART) concept is currently being developed to overcome the limitations of traditional avionics design. The SMART concept is based upon two multi-functional modules that can be reconfigured to drive and sense a variety of mechanical and electrical components. The SMART units are key to a distributed avionics architecture whereby the modules are located close to or right at the desired application point. The drive module, SMART-D, receives commands from the main computer and controls the spacecraft mechanisms and devices with localized feedback. The sensor module, SMART-S, is used to sense the environmental sensors and offload local limit checking from the main computer.

There are numerous benefits that are realized by implementing the SMART system. Localized sensor signal conditioning electronics reduces signal loss and overall wiring mass. Localized drive electronics increase control bandwidth and minimize time lags for critical functions. These benefits in-turn reduce the main processor overhead functions. Since SMART units are standard flight qualified units, DDT&E is reduced and system design can commence much earlier in the design cycle. Increased production scale lowers individual piece part cost and using standard modules also reduces non-recurring costs. The benefit list continues, but the overall message is already evident: the SMART concept is an evolution in spacecraft avionics. SMART devices have the potential to change the design paradigm for future satellites, spacecraft and even commercial applications.

## SMART: The Future of Spaceflight Avionics

### Extended abstract:

#### Introduction

A novel avionics approach is necessary to meet the future needs of low cost space and lunar missions that require low mass and low power electronics. The current state of the art for avionics systems are centralized electronic units that perform the required spacecraft functions. These electronic units are usually custom-designed for each application and the approach compels avionics designers to have in-depth system knowledge before design can commence. The overall design, development, test and evaluation (DDT&E) cycle for this conventional approach requires long delivery times for space flight electronics and is very expensive.

#### Traditional Space flight Avionics approach

The traditional approach to designing space craft avionics is to define the specifications for the system begin conceptual design and advance that design through various reviews (e.g., PDR, CDR, etc.). The electronics may be prototyped at this point and this unit may either become the proto-flight unit or be used as an evaluation unit for various purposes. Generally a typical avionics system will have similar functional blocks as shown in figure 1. Since each flight system is usually unique, some of these functions may or may not be included.

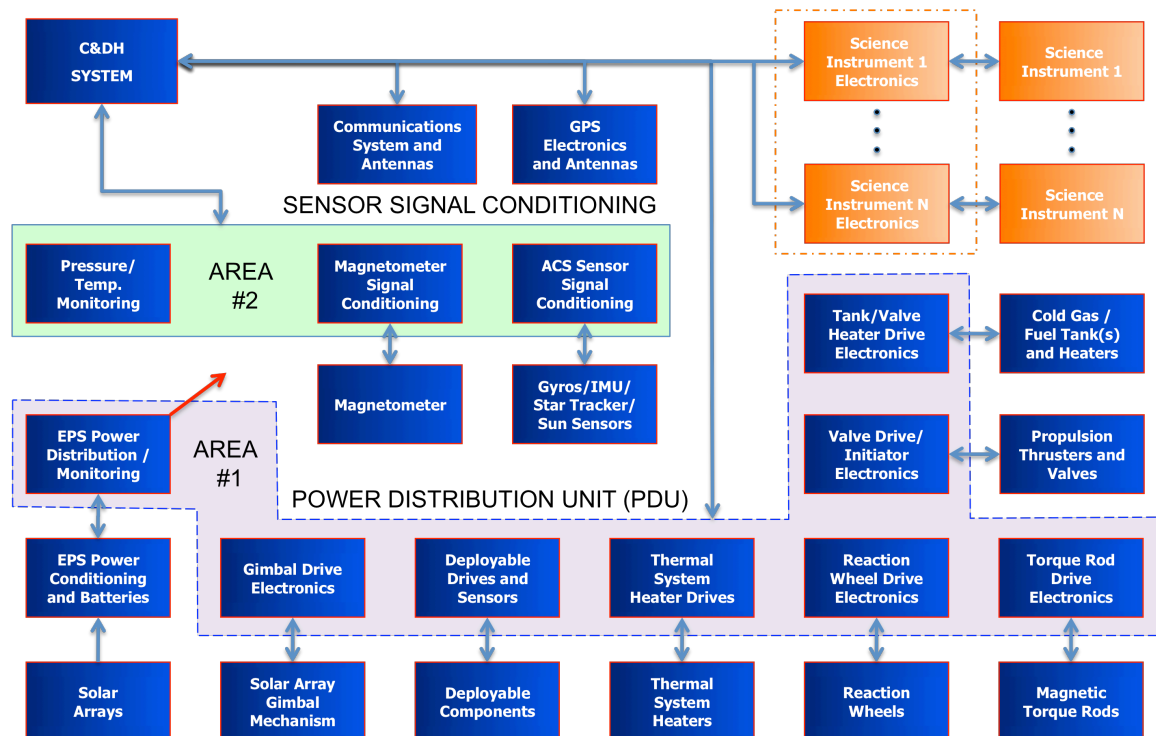


Figure 1 – Typical Avionics System Block Diagram

## SMART Approach to Spacecraft Avionics design

The Small Multi-purpose Advanced Reconfigurable Technology (SMART) concept is currently being developed to overcome the limitations of traditional avionics design. The SMART concept is based upon two multi-functional modules that can be reconfigured to drive and sense a variety of mechanical and electrical components. The SMART units are key to a distributed avionics architecture whereby the modules are located close to or right at the desired application point. The drive module, SMART-D, receives commands from the main computer and controls the spacecraft mechanisms and devices with localized feedback. The sensor module, SMART-S, is used to sense the environmental sensors and offload local limit checking from the main computer.

The SMART-D modules are designed to replace typical Power Distribution Unit (PDU) functions. These control functions are shown in the shaded area portion #1 in figure 1. In addition, the SMART-D unit can serve as an electrical power controller for other systems. The SMART-S module is designed to perform the sensor signal conditioning functions. In figure 1, these sensor functions are shown in shaded area #2. Also, the SMART units can be used to perform some if not all the functions necessary for the scientific instruments. These are shown in the upper right corner of figure 1.

## SMART Development History

The SMART development has roots in several previous NASA projects. Initially the concept was based upon the Programmable Thermostat Module (PTM) and Data Recorder Module (DRM) developed for the Multi-Purpose Logistics Module (MPLM). The PTM and DRM designs evolved into the Remote Data Acquisition (RDAQ) modules developed for the Fast, Affordable, Science and Technology SATellite (FASTSAT). The RDAQ modules were fielded in distributed avionics architecture within the FASTSAT system. During the RDAQ development, it was envisioned that only two multi-functional modules could replace the nine different RDAQ designs developed for FASTSAT. Thus the SMART design concept was initiated.

## Similar Endeavors

Several endeavors have been undertaken which approach the multi-functionality of the SMART concept. Around 1998, BAE systems developed the X-33 Remote Health Monitoring Node. This unit performed sensing functions for various sensors for the X-33 vehicle. The GE aviation group developed and markets their Remote Interface Unit (RIU) for aircraft systems. These RIU units provide the sensor signal conditions for an array of sensor types. In addition to sensor inputs, several channels of discrete output and switched output current are available. Currently, the Air Force Research Laboratory (AFRL) is developing the Space Plug-and-play Avionics (SPA) system. The AFRL concept is based upon a small remote terminal that connects various sensors and components into the SPA network. The SPA remote terminal is the Appliqué Sensor Interface Module (ASIM). NASA has recently been developing a Remote Electronics Unit (REU) for the extreme temperature and radiation space environment. The REU is

intended to miniaturize the sensing functions into a single connector to minimize mass and power in the sensor systems.

Each of these similar multi-functional designs has its advantages and disadvantages. The intent of this exposition is not to debate the merits of each concept. Alternatively, the intent is to showcase the multi-functionality of the SMART concept and how it challenges the traditional space avionics design paradigm.

### Distributed Architecture Advantages

Distributed avionics systems offer several advantages over conventional centralized architectures. Centralized systems require high-speed processors and communication pathways, which are complex, costly and have significant radiation issues. Mission costs are reduced in a distributed network of electronic drivers and sensor signal conditioning electronics because the overall electrical system requires less wiring mass. In a distributed architecture, the individual drivers and sensor modules are considered line replacement units and thus faults are discovered and repaired more easily.

### SMART Benefits

There are numerous benefits that are realized by implementing the SMART system. Localized sensor signal conditioning electronics reduces signal loss and overall wiring mass. Localized electronic drives increase control bandwidth and minimizes time lags for critical functions. These benefits in-turn reduce the main processor overhead functions. Since SMART units are standard flight qualified units, DDT&E is reduced and system design can commence much earlier in the design cycle. Increased production scale lowers individual piece part cost and using standard modules also reduces non-recurring costs.

The benefit list continues, but the overall message is already evident: the SMART concept is an evolution in spacecraft avionics. SMART devices have the potential to change the design paradigm for future satellites, spacecraft and even commercial applications.